

REMARKS**Claim Amendments**

Claim 16 has been amended to require the polymer film in step a) to comprise at least 10% by weight vinyl containing sulphonic acid after swelling. Analogous amendments have been made to Claims 30 and 34. New Claim 36 is identical to Claim 16, but requires at least 30% by weight vinyl containing sulphonic acid to be present after swelling. Support for these amendments is found on page 6, lines 30-35 and page 25, lines 30-39.

New Claims 37-39 have been added which are identical to original Claim 16, but require at least 30%, 50% and 60%, respectively, by weight of the liquid swollen polymer film to be polymer film. Support for these amendments is found on page 6, lines 30-35 and page 25, lines 30-39.

Claim Rejections Under 35 U.S.C. 102/103(a)

(1) Rejection of Claims 16-22 and 24-29 under 35 U.S.C. §§102(b), 102(e) or 103(a) over U.S. 5,643,968 ("Andreola")

The Examiner rejected the pending claims as anticipated by, or, in the alternative, as being obvious over Andreola. The Examiner stated that Andreola discloses ion exchange membranes comprising graft copolymer having a backbone of a first polymer and a polymerizable vinyl monomer containing ion exchange functional groups. The Examiner also stated that suitable backbone polymers include any polymer containing aromatic rings, inclusive of those containing nitrogen, oxygen or sulfur atoms. Suitable functional vinyl monomers include amides and esters of vinylsulfonic acid. The Examiner concluded that Andreola describes the product such as would result from practicing the step recited in base Claim 16.

Applicants respectfully direct the Examiner's attention to Andreola, column 2, lines 37-46, in which Andreola describes that the polymerized vinyl or ring compound is grafted onto the first polymer:

The present invention provides ion exchange membranes comprising a soluble graft copolymer comprising a backbone of a first polymer having a main chain containing aromatic rings and at least one polymerized vinyl or ring compound having ion exchange functionality wherein said polymerized vinyl or ring compound is anionically grafted onto said first

polymer on at least one of said aromatic rings or at least one benzylic carbon atom of said aromatic ring, and specific novel graft copolymers are also disclosed. [*Emphasis added.*]

As such, there is only one polymer in the composition of Andreola, namely, the one in which an ion exchange functionality (*i.e.* a charged group) is grafted onto an aromatic backbone.

In contrast, the claimed proton-conducting membranes comprise an inter-penetrating network of two independent polymers. Indeed, Claim 16 stipulates that vinyl-containing sulfonic acid is *mixed* with another polymer (by imbuing a polymer film in step (a) of Claim 20), and that the vinyl-containing sulfonic acid is then *polymerized* within the polymer film. The polymerized vinyl-containing sulfonic acid forms a second, independent, polymer and is not, as in Andreola, grafted onto the first polymer. Thus, the material that results from performing the steps recited in Claim 16 is different from the material disclosed by Andreola.

Nor does Andreola render the claimed invention obvious since nothing in Andreola teaches or suggests the use of a mixture or a blend of interpenetrating polymers rather than a single graft polymer.

Reconsideration and withdrawal of the rejection are respectfully requested.

(2) *Rejection of Claims 16-22 and 24-29 under 35 U.S.C. §§102(b), 102(e) or 103(a) over U.S. 6,607,856 ("Suzuki")*

The Examiner rejected the pending claims as anticipated by, or, in the alternative, as being obvious over Suzuki. The Examiner stated that Suzuki discloses a solid polymer electrolyte membrane containing backbone polymer having functional chelate groups such as sulfonic acid and phosphonic acid groups. The Examiner further stated that the membrane of Suzuki possesses proton-conductivity of greater than 0.01 S/cm. The Examiner concluded that the membrane of Suzuki is the same as the membrane claimed in Claim 16 of the instant application.

Applicants disagree with the Examiner's interpretation of Suzuki and with the Examiner's conclusion.

Suzuki generally teaches conducting polymer electrolyte membranes which include chelate groups which trap metal ions that contribute to formation of peroxide radicals harmful to

the membrane (Suzuki, col. 6, lines 55-65). The chelate groups are introduced into the membrane in one of two ways: either by direct chemical bond (Examples 6-13) or by mixing the conducting polymer with the compounds that possess chelate groups (Examples 1-5, 14 and 15). (See col. 6, lines 50-54 of Suzuki for general description). Chelate groups can be phosphonic acid groups, carboxylic acid groups or nitrogen.

The membranes described by Suzuki in his Examples are based on ethylene-tetrafluoroethylene copolymer onto which polystyrene chains have been grafted, "ETFE-g-PSt". For example, the membrane of Example 1 of Suzuki comprises a first polymer (ETFE-g-PSt) doped with a second polymer (polyvinylphosphonic acid); Example 13 describes a single type of a polymer based on ETFE-g-PSt, modified to include aminodiacetic groups, and further derivatized using chlorosulfuric acid to introduce sulfonic acid groups into available styrene units (col. 19, lines 53-59).

The process of Suzuki's Example 1 includes a step in which long polymeric chains of polyvinylphosphonic acid are allowed to mix with pre-existing polymer matrix (see, *e.g.* Example 1, column 9, lines 45-55). One of ordinary skill in the art of polymer science will appreciate that such a process runs against steric, electrostatic and other physical limitations inherent in trying to thread polymer chains through one another.

In contrast, Claim 16 recites that vinyl-containing sulfonic acid is being imbued (by using a solution carrying this acid) into *another polymer* (step (a) of Claim 16), followed by *polymerization* of the vinyl-containing sulfonic acid *within the polymer* of step (a). In other words, Claim 16 defines a membrane that comprises a polymer (polyvinylsulfonic acid) *polymerized within* another polymer. Furthermore, it is clear from the term "swelling" in Claim 16 that monomers of vinyl-containing sulfonic acid are concentrated throughout the volume of the polymer film. Applicants also note that Claim 17 expressly stipulates that the polymer film of step (a) increased its volume ("exhibited swelling") by at least 3% due to concentration by the liquid containing sulfonic acid monomers throughout the polymer.

One of ordinary skill in the art will appreciate that a material prepared by the process claimed in Claim 16, the process that includes *in situ* polymerization of a monomer that was allowed to mix and concentrate with a pre-existing polymer matrix, will produce a material having much higher degree of interpenetration of two types of polymer chains than a material

produced by allowing one type of polymer chains to diffuse through another type. Thus, the membranes of Claim 16 are materially different from membranes prepared by the method of Example 1 of Suzuki.

In Example 13, no polymerization takes place at all. Rather, a single type of graft polymer, ETFE-g-PSt, is derivatized to include both sulfonic acid groups and chelating amines. It is clear that the membranes of Suzuki's Example 13 are different from the membranes of Claim 16, which comprise interpenetrating network of two different polymers.

Thus, Example 1 and Example 13, referred to by the Examiner, fail to anticipate Claim 16. Nor does the remainder of the Suzuki disclosure anticipate Claim 16.

It is noted that Example 18 describes immersing a graft ETFE-g-PSt polymer in a mixture comprising 10 wt % vinyl phosphonic acid and 0.5 wt % divinylbenzenesulphonic acid and then polymerizing. Example 18 further describes that the doping ratio is 9 wt % after immersion and 7 wt % after polymerization. Taking into account that there is a 20 fold excess of vinyl sulphonic acid relative to divinylbenzenesulphonic acid, the content of divinylbenzenesulphonic acid in the polymer is only 0.45 wt % after immersion and only 0.35 wt % after polymerization. Claim 16, as amended requires in step a) that the polymer film comprises after swelling at least 10 % by weight vinyl-containing sulphonic acid. As such, Claim 16 requires over an order of magnitude more vinyl-containing sulphonic acid to be present than in Example 18. This difference is even greater for new Claims 37-39. As such, the claimed subject matter is novel in view of Example 18.

Nor does Suzuki render the claimed invention obvious. Nothing in Suzuki teaches or suggests the use of *in situ* polymerization within a polymer matrix using the quantity of vinyl-containing sulphonic acid monomer required by Applicants' claims. It is noted that sulphonic acid groups in the compositions of Suzuki serve the purpose of being electrolytes. However, this electrolytic function in Example 18 is provided by the sulphonic acid groups on the graft ETFE-g-PSt polymer. The purpose of the divinylbenzenesulphonic acid groups is only to crosslink the polymerized vinylphosphonic acid monomers, not to provide an electrolyte. As such, the person of ordinary skill in the art would have no reason to increase the amount of divinylbenzene sulphonic acid over ten fold to the level required by Applicants' amended claims. As such, the claims are non-obvious in view of Suzuki.

Furthermore, Applicants' membranes possess unexpected advantages such as having low permeability, thus being suitable for use with pure hydrogen or methanol (page 5, lines 28-32 of the English translation), high conductivity (page 5, lines 35-37 of the English translation), and high mechanical stability (page 6, lines 1-3 of the English translation).

Reconsideration and withdrawal of the rejection are respectfully requested.

(3) Rejection of Claims 16-22 and 24-29 under 35 U.S.C. §§102(b), 102(e) or 103(a) over U.S. 6,248,469 ("Formato")

The Examiner rejected the pending claim as anticipated by, or, in the alternative, as being obvious over Formato. The Examiner stated that Formato discloses a solid polymer electrolyte membrane having porous polymer substrate interpenetrated with ion-conducting material. The preferred ion-conducting material includes polyvinyl sulphonic acid. The Examiner also stated that one of the methods of producing the membranes of Formato comprises the step of preparing the substrate polymer, impregnating the substrate with a monomer, and polymerizing the monomer *in situ* to form the composite membrane.

Applicants submit that the substrate polymer of Formato is materially different from the polymer of step (a) of Applicants' Claim 16 (the polymer film being swelled with liquid comprising vinyl-containing sulfonic acid), and that, therefore, the composite membranes resulting from the methods of manufacturing described by Formato are also materially different from the membrane of Claim 16.

Applicants direct Examiner's attention to column 12, lines 28-47 of Formato, where the general method of preparation of his membranes is described. Specifically, the substrate polymer is formed into film (col. 12, lines 33-36), and then immersed in water, which leaches out solvent and coagulates polymer (col. 12, lines 36-39). This process forms voids (col. 12, line 40). Ion-conducting material is then introduced into these voids either by solvent-exchange process (column 12, lines 41-42), or by infiltrating a dry membrane (column 12, line 43). This description is consistent with FIG. 1, which is a schematic illustration of the process by which Formato's membranes are prepared. (Applicants note that express description of FIG. 1 is not found in Formato.) It is clear from panel A of FIG. 1 that micropore regions (*i.e.* the regions in which "voids" were formed by solvent leaching) are separate and distinct from polymer regions

(i.e. regions in which no “voids” were formed). Turning now to panel B of FIG. 1, it is clear that whether solvent-exchange or infiltration variant of the process of Formato is used, the ion-conducting material can only find its way into the micropore regions, and not into the polymer regions. (Applicants particularly note that the two types of regions are expressly marked by different labels in panel C of FIG. 1.)

Thus, the membrane of Formato, even if prepared by employing *in situ* polymerization of the ion-conducting material, will have bulk regions in which no ion-conducting material will be present. This is to be contrasted with the membranes of the present invention, which are not taught to contain voids, or micropores. This is because no leaching of solvent by water, as described by Formato, is performed. Instead, a polymer film of step (a) of Claim 16 is imbued with vinyl-containing sulfonic acid, which is then polymerized *in situ*. As a result, the membranes of the present invention lack bulk regions of the polymer substrate from which ion-conducting material is absent (such as “substrate polymer regions” shown in panel C of FIG. 1 of Formato). Accordingly, the membranes of Claim 16 are materially different from those of Formato.

Nor does Formato render Claim 16 obvious. Formato’s invention relies on filling the micropores in the substrate polymer with ion-conducting material. Thus, Formato neither teaches nor suggests any other method of interpenetrating one polymer with another, ion-conducting, polymer. Furthermore, Applicants’ membranes possess unexpected advantages such as having low permeability, thus being suitable for use with pure hydrogen or methanol (page 5, lines 28-32 of the English translation), high conductivity (page 5, lines 35-37 of the English translation), and high mechanical stability (page 6, lines 1-3 of the English translation).

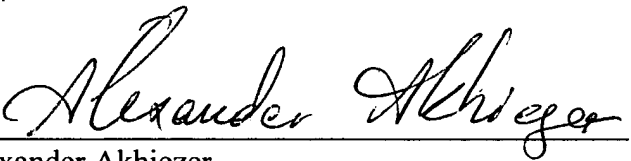
Reconsideration and withdrawal of the rejection are respectfully requested.

CONCLUSION

In view of the above remarks, it is believed that all claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS,
P.C.

By 

Alexander Akhiezer

Registration No. 54,617

Telephone: (978) 341-0036

Facsimile: (978) 341-0136

Concord, MA 01742-9133

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